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by

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Community Air Pollution Program

U. S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

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Introduction

A two-month (Jan. 16 - March 15, 1956) study was undertaken to learn the probative value of a single field sampling station in determining whether air pollution experienced by a residential area in one city, St. Bernard, Ohio, was primarily attributable to a suspected group of industrial sources in that city, or to sources within the adjacent village of Elmwood Place and the surrounding city of Cincinnati. The situation is representative of a whole class of air pollution problems wherein the source and receptor may be in separate jurisdictions thereby preventing the receptor jurisdiction from making intensive source emission studies as would normally be done were both source and receptor in the same control jurisdiction. In this particular situation, jurisdictional relationships were still further complicated by the fact that both of the smaller communities are completely surrounded by a third, Cincinnati, Ohio, and are subject to the generalized air pollution of the greater Cincinnati metropolitan complex of over a million population. The industrial sources suspected are mainly a group of chemical plants producing sulphuric acid, superphosphate fertilizer, detergents, dyes and intermediates.

Sampling Station

Since the study was made at the request of the St. Bernard Board of Health, the sampling site had to be in St. Bernard, as near as possible to the receptor residential area and as nearly as possible in a direct line between suspected sources and receptor area. An isolated and unused one-story public playground building meeting these specifications was therefore selected as the sampling site (Fig. 1). The contours on the map show its location to be on a relatively flat slope in somewhat hilly terrain. The instrumentation installed in this building was (Fig. 2, from left to right) a pair of Esterline-Angus continous recorders for wind direction and velocity respectively; a Beckman-Whitley translator unit(1) for the above recorders wired to a Beckman-Whitley wind vane and anemometer(1) mounted atop a 50 foot pole 100 yards due west of the building; and Aseco auto-impinger, (2) used at different times during the study for the measurement of oxides of nitrogen or SO_2 on an hourly cycle (i.e. 41 minutes of each hour); a National Air Sampling Network type high-volume glass fiber filter sampler(3) operated on a 24-hour cycle; an AISI hydrogen sulphide sampler(4) operated on a 6-hour cycle, and an AISI tape sampler(5)(6) operated on a 3-hour cycle. The sampling tube to the right of the photograph goes to a Thomas Autometer (7) not shown in the picture, which continously recorded the SO_2 level on a strip chart.

All sampling tube intakes were approximately 12 feet above ground level except the hi-vol sampler inlet which, as shown, was at a somewhat lower elevation. Once installed, all samplers were kept in operation 24 hours per day, seven days per week for the remaining duration of the study, except for outage due to instrument failure. Because installation of equipment was spread over several weeks and because repair outage differed between instruments, the length of record is longer from some instruments than others. The actual length of records are as follows:

Wind direction and velocity	48 days
H_2 S Sampler	48 days
AISI Sampler	40 days
Autometer	28 days
Automatic Impinger (SO_2)	15 days
Automatic Impinger (Oxides of Nitrogen)	4 days
High-Volume Sampler	23 days

Usefulness of Results Obtained

Data from three of the above seven sets of records were found to have no probative value in answering the question posed by the study. The hydrogen sulphide sampler gave no usable data because, despite the fact that the tape was proven sensitive to H_2S, no discoloration was detected during the entire 1152 hours it was run.

Automatic impinger data for NO_2 were also unusable in this respect because it was demonstrated during the study period that at the flow rates employed, with the background of SO_2 present and the Saltzman reagent[8] technique used, the automatic impinger was not satisfactory for this measurement. The sampling efficiency was not high enough for the results to be reliable. In fact, on several occasions, oxides of nitrogen that could be detected by odor and visibly traced as a plume from the source were not detected by the impinger sample. Automatic impinger operation for SO_2 (by conductivity of samples) was generally satisfactory. However, because the Autometer yielded the same information as the Auto-impinger but with greater detail, Autometer data were used in preference to Auto-impinger data for SO_2.

Correlation of SO_2 and Dirt Shale with Wind Direction

Of the remaining records, two could be correlated with wind data because the data from the Autometer were continuous and those from the AISI sampler represented 3-hour cycles. The remaining sampler, the high-volume, being on a 24-hour cycle, does not lend itself to correlation with wind direction and velocity because of the variations of wind conditions over a 24-hour period.

Average SO_2 and dirt shade values in St. Bernard were comparable with those found elsewhere in greater Cincinnati during the study period except that considerably higher dirt shade values were observed at the downtown Cincinnati station. However, the analysis of SO_2 and dirt shade data with respect to wind direction (Table I and II) shows a definite tendency for winds from the northerly directions to be more polluted than those from southerly directions. More specifically, winds from N and NNE had SO_2 concentrations three to four times the average for other wind directions and winds from the northerly sectors of WNW through E had a mean dirt shade of 9.8 compared to 6.4 for the remaining 180° of southerly sector. Since the suspected sources lie N and NE of the sampling site, this finding is significant.

Data From High Volume Filter Samples

High-volume samples were taken at the rate of approximately 50 cfm through 8" x 10" tared glass fiber filters for 24 hours after which the filters were again weighed. Portions of the filters were used for analysis of the collected particulate matter for sulphates, nitrates, and chlorides, using National Air Sampling Network techniques. (9) The suspended particulate determined in this manner was considerably higher in St. Bernard than in a comparative site in greater Cincinnati (Table III). There was also a marked excess of sulphates in the St. Bernard samples over those for downtown Cincinnati.

This excess is most likely attributable to the suspected industrial sources, particularly the sulphuric acid plant, visible plumes from which could from time to time be readily observed traveling to and above the sampling site.

A portion of each filter was extracted with benzene for eight hours. A much larger amount of benzene extractable material was found in these samples over those from the Cincinnati site (Table III). Not only was the benzene extractable content of St. Bernard air high in comparison with both downtown Cincinnati and other cities in the United States, but also the percent of neutral aliphatic hydrocarbons in a composite sample (of all the St. Bernard benzene extract samples) (Table IV) was also high in similar comparison. The amount of neutral aliphatic hydrocarbons normally found is in the range of from 15 to 30 percent of the benzene soluble material. Thus the neutral aliphatic hydrocarbon content of St. Bernard air was, during the test period, from two to five times higher than that normally found elsewhere. Until a better explanation can be found, this also must be attributed to the only likely sources of neutral aliphatic hydrocarbons - one or more of the chemical plants in the group of suspected sources.

Conclusions based on high volume sample analysis cannot be considered too firm because the wind pattern during the study period (Table V) was predominantly from the southwest quadrant.

There was, however, a strong enough component from the northeast quadrant to have transported pollution from the north and northeast into the receptor area. If the suspected source-receptor transport does occur, still higher benzene extractable, aliphatic hydrocarbons, sulphate, and nitrate values might be expected to occur when the weather regime involves a higher percentage of wind from the suspect directions.

Conclusion

The combination of an excess of sulphates, nitrates and aliphatic hydrocarbons in St. Bernard air over concentrations elsewhere in greater Cincinnati, an excess of SO_2 and dirt shade associated with northerly winds, and visual observation of the travel of plumes from suspected sources confirm the suspicion that the alleged group of industrial sources are the cause of complaints of odorous air pollution in certain residential areas of St. Bernard. This study shows that it is possible to draw this limited type of conclusion from a short term study using a single air sampling station.

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TABLE I

RELATION OF DIRT SHADE TO WIND DIRECTION

Northerly wind directions	Dirt shade RUDS	Southerly wind directions	Dirt shade RUDS
WNW	8.3	ESE	9.4
NW	7.3	SE	6.0
NNW	9.2	SSE	3.5
N	8.3	S	7.7
NNE	10.7	SSW	6.1
NE	9.0	SW	6.8
ENE	9.4	WSW	6.3
E	12.6	W	7.2

TABLE II

RELATION OF SULFUR DIOXIDE LEVELS TO WIND DIRECTION

Northerly wind directions	Ave. conc. SO_2 ppm	Southerly wind directions	Ave. conc. SO_2 ppm
WNW	.038	ESE	.022
NW	.023	SE	.008
NNW	.030	SSE	.013
N	.079	S	.017
NNE	.048	SSW	.015
NE	.020	SW	.014
ENE	.025	WSW	.030
E	.021	W	.018

TABLE III

COMPARISON OF ST. BERNARD AND CINCINNATI*
AIR PARTICULATE SAMPLES

Date	City	AMOUNT, µg/Cu M				
		Suspended particulate	Benzene soluble	Sulfates	Nitrates	Chlorides
1/25/56	St. Bernard	421	41	42.5	10.8	1.0
	Cincinnati	198	17	28.7	1.1	0.3
2/8/56	St. Bernard	291		14.7	2.3	0.3
	Cincinnati	229		10.9	0.5	0.5
2/15/56	St. Bernard	228	29	25.2	4.5	0.1
	Cincinnati	145	9	12.8	0.4	0.4
3/1/56	St. Bernard	216	99	9.0	1.3	0.2
	Cincinnati	104	9	7.3	0.5	0.8
3/7/56	St. Bernard	142	86	10.3	0.9	0.3
	Cincinnati	88	13	13.1	0.4	0.7
3/14/56	St. Bernard	335	43	45.4	10.8	0.9
	Cincinnati	159	13	25.6	1.1	0.4
Average	St. Bernard	272	59	24.5	5.1	0.5
	Cincinnati	154	12	16.4	0.7	0.5

*Lincoln Park Drive Station

TABLE IV

FRACTIONATION OF COMPOSITE SAMPLE

OF BENZENE SOLUBLE MATTER

Fraction	Percent of total		
	St. Bernard	Cincinnati	Los Angeles
Aliphatic hydrocarbons	65.6	33.0	19.0
Aromatic hydrocarbons	14.1	19.0	14.3
Neutral oxygenated hydrocarbons	6.8	24.0	18.2
Acids: phenols, acids, etc.	3.8	lost	18.0
Insoluble in ether and water	2.0	9.7	13.3
Bases: amines, etc.	1.2	0.9	0.2
Water soluble	1.0	0.6	5.5
Losses on analysis	5.5		11.5
	100.0		100.0

TABLE V

WIND PATTERN DURING STUDY

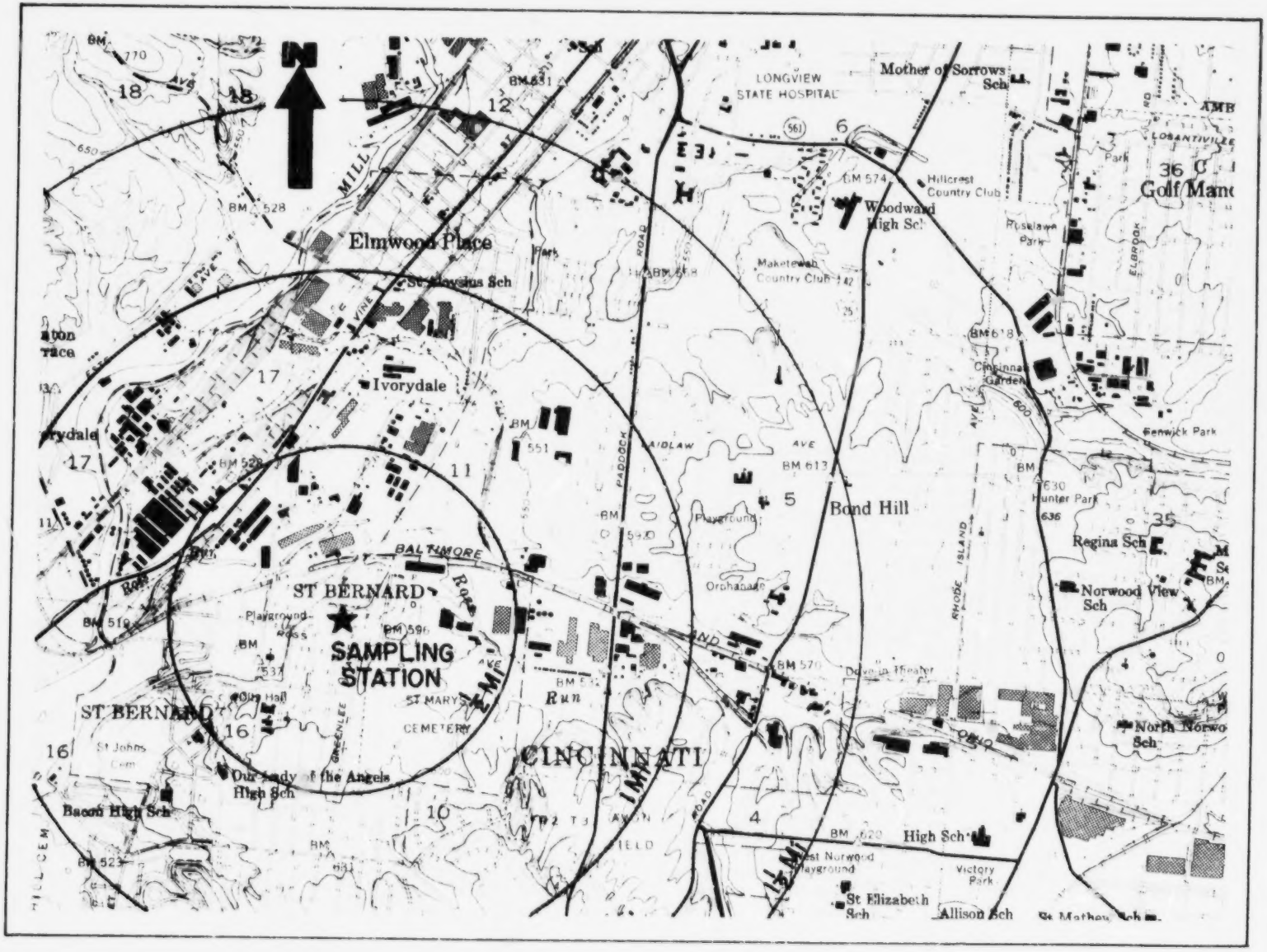
Northerly wind directions	Percent	Southerly wind directions	Percent
WNW	3.2	ESE	5.2
NW	6.4	SE	1.2
NNW	5.6	SSE	0.8
N	3.6	S	[illegible]
NNE	6.0	SSW	10.4
NE	12.4	SW	8.0
ENE	4.4	WSW	12.9
E	10.4	W	6.8

CAPTIONS OF FIGURES

1. Map of the St. Bernard area.

2. Sampling Instruments.

Left to right: Esterline-Angus, continuous recorders for wind direction and velocity; Beckman-Whitley Translator unit; Aseco Auto-impinger; Hi-Vol Sampler; AISI Hydrogen Sulphide Sampler; and AISI Tape Sampler.



ST. BERNARD AREA

Figure 1

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Figure 2

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